LOW POTASSIUM JUICE, METHOD FOR PRODUCING THEREOF AND FOOD CONTAINING THE SAME

FIELD OF THE INVENTION

The present invention relates to a low potassium juice, a method for producing thereof and a use thereof, and more particularly to a low potassium juice with a favorable flavor, a method for producing thereof and a food in which the low potassium juice is used as a raw material. The flavor of the potassium juice is improved by decreasing the concentration of potassium and by adding a calcium compound thereto. Further, the present invention relates to a low potassium juice and a food utilizing the same, which are suitable for patients suffering from kidney failure who are allowed to take limited amounts of potassium and to whom administration of calcium carbonate is necessary.

BACKGROUND OF THE INVENTION

In cells of animals inclusive of humans, potassium mainly exist in an intracellular fluid and in a pair with sodium which exists mainly in an extracellular fluid and plays an important role in maintaining the homeostasis of a living organism as one of major factor in the acid-base equilibrium. However, since patients suffering from kidney failure have decreased functions of discharge of potassium and of maintaining blood ion balance so that they tend

to suffer from hyperkalemia, hyperphosphatemia, or hypocalcemia. An extreme increase in serum potassium level may cause the stop of the heart function and, in the worst cases, fatal situation.

Therefore, patients with kidney failure are subjected to strict restriction on the uptake of potassium and, in particular, they cannot freely take fruit or vegetables containing potassium in large amounts. As described above, patients with kidney failure tend to be suffering from hyperphosphatemia or hypocalcemia, and hence administration of calcium carbonate to such patients is necessary. Further, in the case of those patients who are subjected to the restriction on the uptake of fruit and vegetables, there arises a new problem that the contents of meal are unbalanced and it is difficult to maintain a nutritional balance.

Treatment of juice with ion exchange resins itself is a technology which has been known for a long time. J. Sci. Food Agric. (1966), 17(11), 488-90 reports the use of cation and anion exchange resins in preventing the precipitation of argol and adjustment of the acidity of a grape juice. Also, it has been reported a trial to adjust potassium ion in juices using the ion exchange resins (Japanese Patent Application Laid-open No. Sho 61-209573, Brazilian Patent Application Laid-open No. 9704147, European Patent Application Laid-open No. 0339540).

However, foods adjusted to decrease the amount of potassium ion with ion exchange resins by the prior art have not always been

satisfactory in respect of health care, taste, texture, nutritional balance, etc. In the technology described in Japanese Patent Application Laid-open No. Sho 61-209573, since a decrease in the potassium content results in a considerable deterioration of the taste of juice, the amount of depotassification is restricted to 90% or less of the amount of potassium contained in the raw material juice. That is, the taste is maintained by allowing at least about 10% of potassium to remain. Further reduction in the content of potassium is not applied.

According to the guideline used in Japan, patients under maintenance blood dialysis who receives dialysis 3 times a week are subjected to a strict restriction on the uptake of potassium to 1.5 g/day. In this case, if the amount of potassium in juice reamed from fruit or a vegetable is reduced until it is suitable for drinking by patients with kidney failure, the acidity increases excessively and the taste is extremely aggravated so that a drinking having a taste suitable as juice has not been obtained.

Brazilian Patent Application Laid-open No. 9704147 and European Patent Application Laid-open No. 0339540 disclose methods for producing depotassified juice containing water-soluble calcium ions by using calcium type cation exchange resin in order to improve the degree of deterioration of the taste as described above. Brazilian Patent Application Laid-open No. 9704147 discloses the technology of exchanging potassium ions and sodium ions in juice

with calcium ions using calcium type cation exchange resin.

However, the calcium type cation exchange resin is limited in the content of water-soluble calcium salt necessary for the adjustment so that exchange of a large amount of calcium ions is unrealistic and it is only possible to provide juice which contains a trace amount of calcium ions in the range where they are water-soluble as contained in general beverages.

Since use of the calcium type cation exchange resins is unrealistic, European Patent Application Laid-open No. 0339540 discloses a method for producing low potassium juice using novel calcium type cation exchange resin. That is, it discloses a method for producing calcium containing juice using calcium type cation exchange resin composed of polystyrene resin having sulfon groups, crosslinked to 80% with divinylbenzene.

However, also in this case, there are technical barriers, that is the amount of potassium ions removed and volume of exchange by the calcium type cation exchange resin. Therefore, the prior art remains to provide juice still containing potassium ion in an amount of about 30% of the total amount of potassium ion contained in juice before the treatment.

Moreover, nowadays when ion exchange technology has been improved greatly, a method for the decationation of juice by means of ion exchange membranes has also been used widely. However, juice, which has a high solid content, causes clogging of the membrane,

so that a reduction in the amount of ion is limited to about one fifth of the cations contained in raw material juice.

As stated above, in the prior art, it has been known to provide juice by removal of potassium ions using cation exchange resin and optional addition of calcium by use of calcium type cation exchange resin. However, there has been a limitation in technology to remove a sufficient amount of potassium while retaining taste and exchange a large amount of calcium ions by use of calcium type cation exchange resin.

Concerning general methods for freeze-drying juice, the relationship between Bx of the product to be dried and freeze-drying temperature, the necessity of generating ice composed of small crystals and so on are disclosed in "Latest fruit juice/fruit beverage encyclopedia" published on October 1, 1997 by Asakura Publishing Co., Ltd. page 287 (ISBN 4-254-43060-4). However, no mention is made of specific treatments of low potassium juice. Next, concerning general methods for producing jelly and gummy, their formula and production method are described in "Encyclopedia of confectionery" published on May 20, 2000 by Asakura Publishing Co., Ltd., pages 397-400 (ISBN 4-254-43063-9), but no mention is made of products containing low potassium juice. Also, as for general candy, various formulae and production methods are described on pages 386 to 392 of the above-cited "Encyclopedia of confectionery" but no mention is made of products containing low potassium juice

as described above. Furthermore, concerning jelly hot-filled in a soft container equipped with a mouthpiece having a cap and sealed, jelly-like fluid drink containing collagen peptide and peach juice is disclosed in Japanese Patent Application Laid-open No. Hei 11-75726, but no mention is made of products containing low potassium juice.

It is needless to say that taste is one of the important elements of food according to the present invention. Foods from which merely potassium has been removed are not satisfactory to patients suffering from chronic kidney failure who are compelled to be subjected to dietary control for a long period of time. This is a serious problem.

However, scientific clarification of sensation of taste of humans has not been made sufficiently yet and in actualities, novel foods and new tastes have been developed by at random screening and tremendous efforts by food technicians.

SUMMARY OF THE INVENTION

An object of the present invention is to solve the problems associated with the prior art as described above. More particularly, an object of the present invention is to provide a low potassium juice produced by the preparation method described below and various foods such as powdered low potassium juice, jelly, gummy, candy produced from the low potassium juice as a raw material which not

only contain a reduced amount of potassium but also have improved taste and nutritional balance so that it can be taken with good taste for patients who suffer from malfunction for kidney such as kidney failure. In addition it is intended for the therapy of patients with kidney failure, i.e., control of blood potassium ion as well as improvement and prevention of hypocalcemia and hyperphosphatemia with calcium carbonate.

Among others, in the case of patients suffering serious kidney failure, even the amount of water contained in usual juice imposes a large load on the kidney to discharge it and in addition uptake of potassium is strictly limited as described above. On the medical site under such circumstances, simply rock ice or cube ice is given to the patients as a tasty material for limited water uptake. In view of this situation, intensive investigation has been made on low potassium food having a relatively low water content and allowing supplemental uptake of energy originated from carbohydrates and as a result it has been successful to develop various foods containing low potassium juice as described above, thus achieving the present invention.

First, to obtain low potassium juice, intensive search and study have been made in every direction. Decreasing the potassium content with a use of cation exchange resin resulted in an excessive increase in acidity so that low potassium juice of fruit and/or low potassium juice of vegetable which has lost taste could be

obtained. However, addition of a suitable amount of a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice has neutralized the acidity and improved the taste so that it could be taken with good taste. Then, it has been found that the above-described various foods applied from the low potassium juice as a raw material can be used for the therapy of patients suffering kidney insufficiency, for the purpose of maintaining the balance between blood potassium ion and phosphate ion in the body, and for the purpose of supplying energy to the body by carbohydrates inevitably added to various foods containing low potassium juice.

Generally, for the neutralization of acidity, addition of a basic compound is considered. However, addition of a basic substance containing potassium or sodium which has been removed from juice cannot be adopted for juice for patients suffering from kidney failure who are subjected to restriction on the uptake of potassium or sodium. Conventional technologies using calcium type cation exchange resins have limitations on the amount of potassium to be removed and the volume amount of calcium ion to be exchanged as described above.

On the other hand, calcium carbonate is a water-insoluble compound and as described in The Merck Index (12th ed., Merck & Co., Inc., pp271-272), calcium carbonate has been used widely for animals or humans as a supplement for calcium ions and as an

antioxidant. It has been widely administered to patients suffering from kidney failure as described below in order to suppress the absorption of phosphoric acid so that juice containing it or various foods applied from it as a raw material is not only safe when taken by the patients but also is expected to exhibit a suppressing effect on the absorption of phosphoric acid.

In the conventional technologies, it has been tried to solve the problem of taste by use of water-soluble calcium ions. On the contrary, the present inventors have found that the problem can be solved by the addition of water-insoluble calcium carbonate or sparingly water-soluble calcium hydroxide in the solid states. That is, various kinds of juice are taken generally with the mouth feel and taste of the solids contained in fruit or vegetables and on this occasion, the addition of calcium carbonate or calcium hydroxide in the solid state can neutralize excessive acidity without deteriorating the taste. The present invention has been achieved based on this finding.

Since the potassium content varies depending on the kind of the original raw material juice as obtained by reaming fruit or vegetable, the amount of cation exchange resin adapted for the potassium content of each original raw material juice and contact time are taken into consideration in order to produce many kinds of low potassium juice and it has been found that by so doing the above-described various foods using low potassium juice from which

a sufficient amount of potassium has been removed, preferably the amount of potassium has been decreased to less than one-tenth, more preferably no more than one-twentieth of the amount of potassium contained in the original raw material juice as a raw material can be provided.

Further, the present inventors have completed the present invention having the great feature that has not been attained by the conventional technologies that the amount of calcium carbonate can be controlled in accordance with the state of patients suffering from kidney failure. In other words, the present inventors have found that the addition of calcium carbonate or calcium hydroxide in the solid state to juice, which is obtained by sufficiently depotassifying fruit or vegetable juice and has reduced its taste, in amounts or necessary for the therapy of patients suffering from kidney failure can simultaneously solve the problems of taste and consideration for conditions of various foods for patients suffering from kidney failure.

Accumulation of phosphoric acid in the body is an important problem to patients suffering from kidney failure and it has been an important daily subject to limit the uptake of food containing phosphoric acid and suppress the absorption of phosphoric acid. That is, a general doctors' manual in the U. S., The Merck Manual (5th ed., Merck Sharp & Dohme Research Laboratories, pp 1551-1652, esp. pp 1573 (1987)) describes that in patients suffering from

kidney failure abnormal metabolisms of calcium ion, phosphate ion, parathyroid hormone and vitamin D in blood occur, which when left to stand without any treatment will cause hypocalcemia and hyperphosphatemia, and that in daily diet therapy for patients suffering from kidney failure, food containing potassium must be avoided and calcium carbonate, an absorption suppressor for phosphoric acid, must be taken in order to avoid deterioration of hyperphosphatemia.

Therefore, it is reasonable to add calcium carbonate to low potassium juice obtained by treatment with cation exchange resin in order to solve such a problem. In fact, in the therapy of hyperphosphatemia with an absorption suppressor for phosphoric acid, aluminum hydroxide and aluminum carbonate have been conventionally used. Currently, to avoid toxicity, calcium carbonate (0.5 to 1.5 g/day) is administered orally.

The first aspect of the present invention provides low potassium juice having an improved taste obtained by treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, and adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice.

The second aspect of the present invention provides the low potassium juice as claimed in claim 1, characterized in that the

treatment with a cation exchange resin is a column treatment or batch treatment.

The third aspect of the present invention provides the low potassium juice as claimed in claim 1, characterized in that the cation exchange resin is of an H^+ form.

The fourth aspect of the present invention provides a method for producing low potassium juice having an improved taste, characterized by comprising treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, and adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice.

The fifth aspect of the present invention provides the method for producing low potassium juice as claimed in claim 4, characterized in that the treatment with a cation exchange resin is a column treatment or batch treatment.

The sixth aspect of the present invention provides the method for producing low potassium juice as claimed in claim 5, characterized in that the cation exchange resin is of an H^+ form.

The seventh aspect of the present invention provides low potassium juice having an improved taste obtained by treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice

to no more than one-tenth, preferably no more than one-twentieth, adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, and adding organic acid.

The eighth aspect of the present invention provides the low potassium juice as claimed in claim 7, characterized in that the organic acid is at least one organic acid selected from the group consisting of vitamin C, citric acid, malic acid, and lactic acid.

The ninth aspect of the present invention provides the low potassium juice as claimed in claim 7, characterized in that the treatment with a cation exchange resin is a column treatment or batch treatment.

The tenth aspect of the present invention provides the low potassium juice as claimed in claim 7, characterized in that the cation exchange resin is of an H^+ form.

The eleventh aspect of the present invention provides powdered low potassium juice obtained by treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, adding an excipient, and subjecting the mixture to freeze-drying treatment.

The twelfth aspect of the present invention provides the

powdered low potassium juice as claimed in claim 11, characterized in that the treatment with a cation exchange resin is a column treatment or batch treatment.

The thirteenth aspect of the present invention provides the powdered low potassium juice as claimed in claim 11, characterized in that the cation exchange resin is of an H^+ form.

The fourteenth aspect of the present invention provides low potassium juice-containing food, characterized by containing the low potassium juice as claimed in claim 1 or 7, or powdered low potassium juice as claimed in claim 11.

The fifteenth aspect of the present invention provides low potassium juice-containing food as jelly, characterized by comprising the low potassium juice as claimed in claim 1 or 7 or powdered low potassium juice as claimed in claim 11, a gelling agent, a thickener, and carbohydrates.

The sixteenth aspect of the present invention provides low potassium juice-containing food as jelly, characterized by hot filling a heated mixture of food consisting of the low potassium juice as claimed in claim 1 or 7 or powdered low potassium juice as claimed in claim 11, a gelling agent, and carbohydrates in a soft container equipped with a mouthpiece having a cap.

The seventeenth aspect of the present invention provides low potassium juice-containing food as gummy, characterized by comprising the low potassium juice as claimed in claim 1 or powdered

low potassium juice as claimed in claim 11, a gelatin, carbohydrates, an organic acid, and a flavoring.

The eighteenth aspect of the present invention provides low potassium juice-containing food as candy, characterized by comprising the low potassium juice as claimed in claim 1 or 7 or powdered low potassium juice as claimed in claim 11, carbohydrates, and a flavoring.

The nineteenth aspect of the present invention provides low potassium juice for patients suffering from kidney failure, characterized by comprising juice reamed from fruit and/or vegetable being decreased the potassium content thereof to no more than one-tenth, preferably no more than one-twentieth and having 0.5 to 20 g/kg of a calcium compound.

The present invention provides low potassium juice for patients suffering kidney insufficiency, having good taste and maintaining nutrition balance obtained by treating usual juice containing potassium, so-called original raw material juice, with a cation exchange resin to decrease the potassium content of the original raw material juice to less than one-tenth, preferably no more than one-twentieth, adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, and optionally adding vitamin C, citric acid, malic acid, lactic acid, etc., a production method for producing the low potassium juice, and foods containing the low potassium juice. The

foods containing low potassium juice include, for example, powdered juice, nectar, jelly, mousse, jam, pudding, candy, etc.

As described above, specific embodiments of the present invention includes, (1) low potassium juice having an improved taste obtained by treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, and adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, (2) a method for producing a low potassium juice having an improved taste, comprising treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, and adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, (3) low potassium juice having an improved taste obtained by treating juice reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, and adding such organic acid as vitamin C, citric acid, malic acid, lactic acid and mixture thereof, (4) powdered low potassium juice obtained by treating juice

reamed from fruit and/or vegetable with a cation exchange resin to decrease the potassium content of original raw material juice to no more than one-tenth, preferably no more than one-twentieth, adding a calcium compound selected from calcium carbonate and calcium hydroxide in the solid state to the juice, adding an excipient, and subjecting the mixture to freeze-drying treatment, (5) foods containing the low potassium juice or powdered low potassium juice, and (6) low potassium juice for patients suffering kidney failure, comprising juice reamed from fruit and/or vegetable and containing 0.5 to 20 g/kg of a calcium compound, and the potassium content of the juice is decreased to no more than one-tenth, preferably no more than one-twentieth.

DESCRIPTION OF PREFERRED EMBODIMENTS

The original raw material juice used in the present invention includes all the types of juice such as juice obtained by reaming a vegetable, juice obtained by reaming a fruit, and juice obtained by mixing the juices. As for preliminarily concentrated juice, it can be diluted to the concentration of the original raw material juice or the concentration which enables ion exchange treatment as described hereinbelow.

The cation exchange resin used in the present invention may be any of commercially available cation exchange resins, which are adjusted to H^+ form by a conventional method before use. The

treatment with cation exchange resin may be a batch process or a column process. When the treatment is carried out in a batch process, about 20 to 1,000 g of cation exchange resin which is dried per 1,000 g of raw material juice is provided and added it to the raw material juice, followed by stirring for 20 minutes or more, usually for about 30 minutes and filtration.

On the other hand, when the treatment is carried out in a column process, a column packed with about 85 to 500 in weight (g) or volume (mL) of cation exchange resin per 1,000 g of raw material juice is provided and the raw material juice is charged therein and allowed to pass therethrough over 0.5 to 2.0 hours.

Thus, the treatment with cation exchange resin can reduce the potassium content in the raw material juice to one-tenth or less compared with the original content. The potassium content may be reduced to one-twentieth or less compared with the original content depending on the kind of raw material juice, amount of the cation exchange resin used, the contact time in which the juice contacts the cation exchange resin and other factors. In view of productivity and efficiency of ion exchange, the treatment by a column process is preferred.

Further, low potassium juice with improved taste, acidity, and nutrition can be produced by adding to the juice, after the treatment with cation exchange resin to lower the content of potassium, a calcium compound selected from the group consisting

of calcium carbonate and calcium hydroxide in the solid state in an amount of 0.5 to 20 g/kg, preferably to such an extent that the pH of the raw material juice is not returned completely to keep a preservation stability and a taste like the original raw material juice, and if necessary adding vitamin C, citric acid, malic acid, lactic acid, and the like.

Depending on the balance between phosphate ion concentration and potassium ion concentration in blood, patients suffering from kidney failure can take 0.5 to 1.5 g a day of calcium carbonate.

The low potassium juice provided by the present invention may, if necessary, be blended, within the range where no adverse effect to the function of kidney is observed, with various vitamins, carbohydrates, dyestuffs, flavors to impart variation in taste. Of course, the juice can be provided as it is as a beverage. However, if necessary, it may be subjected to preparing into powder or agglomerates in addition to the steps of concentration, drying, and agglomeration. The product in the form of powder or agglomerates can be taken as it is or returned to a liquid state by addition of water, or added to other foods.

EXAMPLES

Hereafter, the present invention will be described in detail by means of examples. However, the present invention is not limited thereto.

In the examples, the cation exchange resin used was commercially available cation exchange resin, Dowex 50W-X4 or SK1B (MITSUBISHI DIA ION Co., LTD.) preliminarily adjusted by the following procedures.

That is, purified water was added to 500 g of the cation exchange resin and the mixture was stirred to sufficiently wash the resin. To the drained resin was added 500 mL of ethanol and the mixture was stirred for 30 minutes. Then, ethanol was removed by filtration. After the washing operation with ethanol was repeated 3 times, ethanol was changed to purified water to conduct washing. To the water-washed resin was added 500 mL of 1M sodium hydroxide solution and the mixture was stirred for 30 minutes. Thereafter, the resin was recovered by filtration. After the operation of the treatment with sodium hydroxide solution was repeated 5 times, the resin was washed with water, until the washing became neutral.

Then, the washed resin was packed in a column, through which was passed 2,500 mL of 3 M hydrochloric acid solution and further the column was washed with water until the washing became neutral. After the above operations, the resin as it was or after sufficiently drying it by suction filtration, served as H^+ form cation exchange resin.

The amounts of ethanol, purified water, 1M sodium hydroxide solution, and washing, etc. may be selected appropriately along with an increase or decrease of the amount of cation exchange resin

used in accordance with the amount of the original raw material juice.

Example 1

Production method in a batch process

The dried H^+ form cation exchange resin in the amount shown in Table 1 was added in 1,000 mL of each of commercially available 100% orange juice, 100% apple juice, 100% grape fruit juice, and 100% grape juice as a raw material juice and the mixture was stirred for 30 minutes to adsorb potassium. Thereafter, calcium carbonate in the solid state in the amount shown in Table 1 was added to each juice after filtration. Further, to each juice was further added vitamin C such that its concentration was equivalent to that of the juice before the treatment as measured by a titration method. The mixture was stirred to dissolve the additives thereby producing low potassium juice, final product.

The concentration of potassium in juice was measured by using Automated Electrolyte Analyzer EA05 (A and T) and the pH of juice was measured by using commercially available pH meter before and after the treatment with the cation exchange resin without the addition of vitamin C. The results are shown in Table 1.

As can be seen from the results, juice having a potassium content reduced to one-tenth or one-twentieth of the original one were produced.

Table 1 Results of treatment of various kinds of juice with ion exchange resin

		Orange juice	Apple juice	Grapefruit juice	Grape juice
Raw material juice (mL)		1,000	1,000	1,000	1,000
Amount of resin used (g)		50	40	50	25
Concentration of potassium (mmol/L)	Before treatment	48.0	25.7	38.6	7.6
	After treatment	2.5	0.8	2.1	0.6
Potassium removal ratio		0.950	0.962	0.947	0.923
pH	After treatment	3.81	4.05	3.30	3.00
	Before treatment	2.18	2.28	2.02	2.07
Amount of calcium carbonate added (g/L)		2.61	2.08	3.65	1.56

Test 1

200 mL of low potassium orange juice having a potassium concentration of 2.5 mmol/L prepared by the method in accordance with that in Example 1 was given to each of patients suffering from kidney failure who were receiving the same dialysis therapy once at the time of dialysis and once at non-dialysis time. The change in blood potassium level in the patients before and after the uptake was measured using Automated Electrolyte Analyzer EA05 (A and T). Table 2 shows the measured values obtained.

From the results, it revealed that the low potassium orange juice produced by the present invention caused no change in blood

potassium level when taken by patients suffering from kidney failure so that it can be given to the patients who suffer from kidney failure safely.

Table 2 Change in blood potassium level when low potassium orange juice is given

Patient	Blood potassium level (mmol/L)			
	Upon dialysis		Upon non-dialysis	
	1 hour before uptake	1 hour after uptake	1 hour before uptake	1 hour after uptake
A	5.5	3.5	5.5	5.5
B	4.9	4.3	4.9	4.9
C	4.5	3.3	4.5	4.5

Example 2

Production method in a batch process

To 1,000 mL of commercially available green-yellow vegetable juice (raw material: celery, parsley, watercress, cabbage, radish, spinach, or trefoil) was added 700 g of cation exchange resin and the treatment with the cation exchange resin was carried out in the same manner as in Example 1 to obtain the vegetable juice from which potassium was removed by adsorption.

Then, to the vegetable juice was added calcium carbonate in the solid state in the amount shown in Table 3 and thereafter vitamin C was added to the vegetable juice such that the concentration was equivalent to that before the treatment as measured by a titration method. The mixture was stirred to dissolve the additives thereby

producing low potassium juice, final product.

Before the treatment with the cation exchange resin and before the addition of vitamin C, the concentration of potassium in juice and the pH of juice were measured in the same manner as in Example 1. The results are shown in Table 3. As can be seen from the results, green-yellow vegetable juice having a potassium content reduced to one-twentieth of the original one were produced.

Table 3 Results of treatment of vegetable juice with ion exchange resin

Amount of juice used (mL)		1,000
Amount of resin used (g)		700
Concentration of potassium (mmol/L)	Before treatment	128.7
	After treatment	6.2
Potassium removal ratio		0.952
pH	After treatment	4.01
	Before treatment	0.99
Amount of calcium carbonate added (g/L)		13.3

Example 3

Production method in a column process

First, 2,000 kg of deionized water was added to 500 kg of 5-fold concentrated orange juice and the mixture was well stirred and mixed and depulping treatment was carried out using a centrifuge. 1,250 kg of the depulped 100% orange juice was collected and weighed.

Moreover, 1,080 kg of deionized water was added to 180 kg of

7-fold concentrated clarified apple juice and the mixture was well stirred and mixed to prepare 100% apple juice.

Further, 85 kg of 6-fold concentrated carrot squeezed juice, 7 kg of 10-fold concentrated tomato squeezed juice, 10 kg of 6-fold concentrated spinach squeezed juice, 190 kg of above 100% orange juice, 43 kg of 7-fold concentrated clarified apple juice, 31 kg of 4-fold concentrated turbid apple juice and 884 kg of deionized water were stirred and mixed well to prepare mixed juice.

The prepared juice used as raw materials were passed through a cylindrical column of 2 m in height and 55 cm in diameter packed with 303 kg of dry H type cation exchange resin SK1B (Mitsubishi Dia Ion) from an upper part thereof over 1 hour, and then solid calcium carbonate were added as they were in the amount shown in Table 4 to produce low potassium juice, final products.

Before and after the treatment with the cation exchange resin, the concentration of potassium in juice were measured using Polarized Zeeman atomic-absorption spectrometer Z-5300 (Hitachi, Ltd.). The results are shown in Table 4.

As can be seen from the results, low potassium juices having a potassium content reduced to one-hundredth or less of the original one were produced.

Table 4 Results of ion exchange resin treatment of various raw material juices in a column process

		Orange juice	Apple juice	Mixed juice
Raw material juice (kg)		1,250	1,250	1,250
Amount of resin used (kg)		303	303	303
Concentration of potassium (mmol/kg)	Before treatment	80.5	29.7	59.5
	After treatment	0.16	0.05	0.15
Potassium removal ratio		0.998	0.998	0.998
pH	Before treatment	3.80	3.68	4.29
	After treatment	1.97	2.30	1.79
After addition of calcium carbonate		3.07	3.22	3.52
Addition amount of calcium Carbonate (g/kg)		2.7	0.8	2.5

Test 2

For various low potassium juice prepared during the steps in Example 3 or as final products, organoleptic tests were carried out before and after addition of calcium carbonate. The tests were carried out by a panel of specialists (20 persons) who had excellent taste discrimination ability. Hedonic scores were as follows.

+2: taste was felt strongly.

+1: taste was felt fairly.

0: unclear whether or not taste was felt.

-1: taste was felt not so much.

-2: almost no taste was felt.

The results expressed by average values of the hedonic scores

obtained are shown in Table 5.

Table 5 Sensory evaluation of taste before and after addition of calcium carbonate

Kind of juice	Before addition	After addition
Orange juice	-1.4	+1.6
Apple juice	-1.8	+1.7
Mixed juice	-1.7	+1.4

Example 4

To 1,250 kg of low potassium orange juice (pH 2.05) prepared in accordance with the method described in Example 3 except that no calcium carbonate was added was added 2.8 kg of solid calcium hydroxide as it was to produce low potassium orange juice (pH 3.25), final product.

The produced low potassium orange juice were evaluated in the same manner as the special panel described in Test 2. The result confirmed that the juice had similar taste to that of the low potassium orange juice to which was added calcium carbonate as described in Example 3.

Example 5

To 28.6 kg of 7-fold concentrated transparent apple juice and 200.0 kg of 4-fold concentrated turbid apple juice was added 771.4 kg of deionized water. The mixture was well stirred and mixed to prepare raw material apple juice.

The raw material apple juice was measured of the potassium content in 1 g by the method of Example 3, which revealed to be 1.10 mg. Subsequently, the column type ion exchange resin treatment was conducted in the same manner as in Example 3 to obtain low potassium apple juice and the amount of potassium in 1 g of the juice was measured by the method of Example 3. As a result, a value of 0.05 mg was obtained.

To 10 kg of the low potassium apple juice were added 1 kg of DE 8 dextrin as an excipient and 10.0 g of calcium carbonate and mixed to obtain low potassium juice containing calcium carbonate. The juice was charged in a tray made of stainless steel to a thickness of 1 cm. The tray was subjected to quick freezing treatment at -25°C for 8 hours and then to ordinary freeze-drying at 26.7 Pa to obtain low potassium powdered juice.

Comparative Example 1

For comparison, in the same manner as in Example 5, dextrin was added to the raw material apple juice obtained in the same manner as in Example 5 without conducting any ion exchange resin treatment and mixed. The mixture was charged in a tray made of stainless steel to a thickness of 1 cm. The tray was subjected to quick freezing treatment at -25°C for 8 hours and then to ordinary freeze-drying at 26.7 Pa to obtain ordinary powdered juice.

Test 3

The low potassium powdered juice obtained in Example 5 and

the powdered juice obtained in Comparative Example 1 were each reconstituted to natural juice concentration corresponding to 100% and taste tests were conducted by a panel of 20 panelists by alternative selection ratio in paired comparison test at a significance level of 5%. As a result, those who preferred the low potassium powdered juice were 40% and those who preferred ordinary powdered juice were 60% so that the results of test indicated no significant difference.

Example 6

6.83 kg of 6-fold concentrated carrot squeezed juice, 0.5 kg of 10-fold concentrated tomato squeezed juice, 0.83 kg of 6-fold concentrated spinach squeezed juice, 15 kg of 100% orange juice obtained in Example 3, 3.43 kg of 7-fold concentrated transparent apple juice, 2.5 kg of 4-fold concentrated turbid apple juice, and 55.15 kg of deionized water were well stirred and mixed to prepare ordinary mixed juice. Subsequently, column-type ion exchange resin treatment was performed in the same manner as in Example 3 to obtain low potassium mixed juice. The low potassium mixed juice was concentrated to Bx 13.3 using a vacuum concentrator.

Separately, a gelling agent mixture consisting of 31.5% by weight of agar, 5% by weight of xanthan gum, 5% by weight of locust bean gum, and 58.5% by weight of glucose and a thickener mixture consisting of 40% by weight of xanthan gum, 40% by weight of locust bean gum, and 20% by weight of glucose were prepared. Then, 514.5

g of stock water was added to 99 g of sugar, 8 g of the gelling agent mixture, and 0.4 g of the thickener mixture and the mixture was well mixed and dispersed and then dissolved at 90°C and mixed to prepare a sugar solution.

On the other hand, to 376 g of the low potassium mixed juice were added 0.24 g of solid calcium carbonate and 1.6 g of a flavoring and further the whole amount of the sugar solution, followed by heating at 60°C. Then, 80 g aliquots were filled in plastic containers and the openings were sealed with an appropriate wrapping material and subsequently pasteurized by a conventional method to obtain jelly.

Comparative Example 2

Citric acid (1.5 g) was added to 376 g of ordinary mixed juice obtained by a method similar to that described in Example 6 without performing any ion exchange treatment with ion exchange resin in order to make the pH equivalent to that of the product in Example 6. Further, 1.6 g of a flavoring was added and the same amount of the sugar solution as in Example 6 was added, followed by heating at 60°C. Thereafter, 80 g aliquots of the mixture were filled in plastic containers and the openings were sealed with an appropriate wrapping material and subsequently pasteurized by a conventional method to obtain ordinary jelly.

Test 4

The amount of potassium in 100 g of the low potassium mixed

juice containing jelly obtained in Example 6 was measured by the method described in Example 3 and the result of 6.46 mg was obtained. On the other hand, the amount of potassium in 100 g of ordinary jelly containing the ordinary mixed juice obtained in Comparative Example 2 was 132.09 mg.

Then, the low potassium mixed juice containing jelly obtained in Example 6 and the ordinary jelly composed of ordinary mixed juice obtained in Comparative Example 2 were subjected to taste tests by a panel of 20 panelists by alternative selection ratio in a paired comparison test at a significance level of 5%. As a result, those who preferred the low potassium mixed juice containing jelly were 45% and those who preferred the ordinary jelly composed of ordinary mixed juice were 55% so that the results of test indicated no significant difference.

Example 7

To 28.6 kg of 7-fold concentrated clarified apple juice and 200.0 kg of 4-fold concentrated turbid apple juice was added 771.6 kg of deionized water. The mixture was well stirred and mixed to prepare raw material apple juice. Subsequently, the column type ion exchange resin treatment was conducted in the same manner as in Example 3 to obtain low potassium apple juice. The low potassium apple juice was concentrated to Bx 13.3 using a vacuum concentrator.

Separately, a gelling agent mixture consisting of 31.5% by weight of agar, 5% by weight of xanthan gum, 5% by weight of locust

bean gum, and 58.5% by weight of glucose and a thickener mixture consisting of 40% by weight of xanthan gum, 40% by weight of locust bean gum, and 20% by weight of glucose were prepared.

Then, 85 g of sucrose, 9 g of the gelling agent mixture, and 0.4 g of the thickener mixture, and 531.3 g of stock water were well mixed and dispersed and then dissolved at 90°C and mixed to prepare a sugar solution. On the other hand, to 375 g of the low potassium apple juice were added 0.35 g of calcium carbonate and 1.0 g of a flavoring and further the whole amount of the sugar solution, followed by heating at 92°C. Then, 150 g aliquots were hot filled and sealed in soft containers each equipped with a mouthpiece having a cap to obtain jelly. The pH of the product was 3.8.

Comparative Example 3

A flavoring (1.0 g) was added to 375 g of ordinary apple juice obtained by a method similar to that described in Example 7 except that treatment with ion exchange resin was not performed and the same amount as in Example 7 of the sugar solution prepared in the same manner as in Example 7 was added, followed by heating at 92°C. Then, 150 g aliquots were hot filled and sealed in soft containers each equipped with a mouthpiece having a cap to obtain jelly. The pH of the product was also 3.8.

Test 5

The amount of potassium in 100 g of the low potassium apple

juice containing jelly obtained in Example 7 was measured by the method described in Example 3 and the result of 5.08 mg was obtained. On the other hand, the amount of potassium in 100 g of ordinary jelly composed of the ordinary apple juice obtained in Comparative Example 3 was 57.84 mg.

Concerning the calcium content in each product, it was 13 mg for the low potassium apple juice containing jelly obtained in Example 7 and 3 mg for the ordinary jelly composed of the ordinary apple juice obtained in Comparative Example 3.

Then, the low potassium apple juice containing jelly obtained in Example 7 and the ordinary jelly composed of ordinary apple juice obtained in Comparative Example 3 were subjected to taste tests by a panel of 20 panelists by alternative selection ratio at a significance level of 5%. As a result, those who preferred the low potassium apple juice containing jelly were 50% and those who preferred the ordinary jelly composed of ordinary apple juice were 50% so that the results of test indicated no significant difference.

Further, ordinary fruit juice jellies commercially available under three different brands were measured of the amount of potassium by the method described in Example 3 and as a result 54.8 mg, 47.3 mg, and 62.3 mg per 100 g of the content were obtained.

Example 8

The low potassium apple juice obtained in Example 5 was concentrated to Bx 13.3 by a vacuum concentrator. 0.035% by weight

of solid calcium carbonate was added to the juice.

In a formulation of 2.9% by weight of the solid calcium carbonate containing juice, 48.5% by weight of sucrose, 48.5% by weight of high maltose corn syrup (containing 25% by weight of water), and 0.1% by weight of a flavoring, sucrose and high maltose corn syrup and water as much as one-third of sucrose were mixed and heated to 160°C and then cooled to 150°C. Then, the flavoring and the solid calcium carbonate containing juice obtained as above were added thereto and the mixture was mixed before it was molded to obtain candy.

The potassium content of the candy was measured by the method described in Example 3 to be 0.002 mg%. Measurement of the calcium content using the analyzer in Example 3 resulted in 1.143 mg%.

Comparative Example 4

The raw material apple juice in Example 5 which was not subjected to the treatment with ion exchange resin was concentrated to Bx 13.3 by a vacuum concentrator. Using the concentrated apple juice of Bx 13.3, ordinary candy was obtained in the same manner as in Example 8 without adding any calcium carbonate.

The potassium content of the candy measured by the method described in Example 3 was 4.505 mg%. Further, the calcium content measured using the analyzer in Example 3 was 0.075 mg%.

Test 6

The candy obtained in Example 8 and ordinary candy composed

of ordinary apple juice obtained in Comparative Example 4 were subjected to taste tests by a panel of 20 panelists by alternative selection ratio in paired comparison test at a significance level of 5%. As a result, those who preferred the candy of Example 8 were 45% and those who preferred the ordinary candy were 55% so that the results of test indicated no significant difference.

Example 9

In a formulation of 5.4% by weight of the low potassium powdered juice obtained in Example 5, 47.0% by weight of sucrose, 47.0% by weight of high maltose corn syrup (containing 25% by weight of water), sucrose, high maltose corn syrup, and water as much as one-third of sucrose were mixed and heated to 160°C and then cooled to 150°C. Then, the low potassium powdered juice, 0.1% by weight of a flavoring, 0.5% by weight of citric acid were added, mixed and molded to obtain candy.

The potassium content of the candy measured by the method described in Example 3 was 0.15 mg%. Further, the calcium content measured using the analyzer in Example 3 was 12 mg%.

Example 10

The calcium carbonate containing low potassium apple juice obtained in Example 5 was concentrated to Bx 14.4 by a vacuum concentrator. In a formulation of 77.040% by weight of the juice, 28.240% by weight of sucrose, 5.780% by weight of powdered sorbitol, 49.906% by weight of acid converted glucose syrup (containing 25%

by weight of water), 6.437% by weight of gelatin, 1.134% by weight of citric acid, 0.341% by weight of malic acid, 0.306% by weight of dyestuff, 0.144% by weight of a flavoring, sucrose, sorbitol, glucose syrup, and water as much as one-third of sucrose were mixed and heated to 125°C to obtain a boiled sugar solution.

On the other hand, gelatin was swollen with 1.5 fold volume of water. Then, the concentrated calcium carbonate containing low potassium apple juice, the boiled sugar solution, and the swollen gelatin were mixed. Finally, citric acid, malic acid, dyestuff, and a flavoring were mixed to obtain a gummy base of Bx79.

Next, the gummy base was cast in a starch mold and left to stand for a whole day and night to obtain molded gummy of Bx 82. The potassium content of the product measured by the method described in Example 3 was 0.8 mg% and the calcium content measured using the analyzer in Example 3 was 6.3 mg%.

Comparative Example 5

The raw material apple juice in Comparative Example 1 which was not subjected to the treatment with ion exchange resin was concentrated to Bx 14.4 by a vacuum concentrator. Using the concentrated apple juice of Bx 14.4, ordinary gummy was obtained in the same manner as in Example 9.

The potassium content of the product measured by the method described in Example 3 was 8.65 mg%. Further, the calcium content measured using the analyzer in Example 3 was 3.3 mg%.

Test 7

The gummy obtained in Example 10 and ordinary gummy obtained in Comparative Example 5 were subjected to taste tests by a panel of 20 panelists by alternative selection ratio in paired comparison test at a significance level of 5%. As a result, those who preferred the gummy of Example 10 were 40% and those who preferred the ordinary gummy were 60% so that the results of test indicated no significant difference.

INDUSTRIAL APPLICABILITY

According to the present invention, there are provided low potassium juice of which the potassium content has been decreased to one-tenth or less, preferably one-twentieth or less as compared with the natural content and a method for producing the juice as well as food containing the juice.

The low potassium juice of the present invention has improved taste by addition of calcium carbonate or calcium hydroxide in the solid state.

The powdered juice, jelly, candy, gummy, etc. produced by use of the low potassium juice have equivalent tastes to that of ordinary food.

The low potassium juice provided by the present invention are suitable for patients suffering from a decrease in kidney function, such as kidney failure, who are subjected to restriction on the

uptake of potassium. Further, the low potassium juice of the present invention and food containing it can be provided for the prevention of hyperphosphatemia in patients suffering from kidney failure.